Long-Term Memory

- Overview: Varieties of LTM.
- Encoding into LTM.
- Retrieval from LTM.
- Implicit Memory.
- Memory as Reconstruction.
A Taxonomy of Memory

Memory

WM (STM)  LTM

Procedural  Declarative

Semantic  Episodic

Implicit Memory
Explicit Memory

Autobiographical
Procedural Vs. Declarative Memory

- **Procedural Memory** - *knowing "how".*
  - memory for skills; "muscle memory".
  - difficult to describe in words.
  - often operates automatically/unconsciously.
Procedural Vs. Declarative Memory

- **Procedural Memory.**
  - Depends heavily on (a) Basal Ganglia & (b) Cerebellum.
  - Impaired in Parkinson's & Huntington's disease.
Procedural Vs. Declarative Memory

- **Declarative Memory** - *knowing "what".*
  - memory for facts and events.
  - things that can be stated or *declared.*
  - Depends heavily on (a) Hippocampus & (b) Cerebral Cortex.
  - Amnesia is an impairment of Declarative Memory.
Semantic Vs. Episodic Memory

- **Semantic Memory.**
  - *general knowledge and facts* about the world that you "know" but can't say where you learned them.
Semantic Vs. Episodic Memory

- **Episodic Memory.**
  - memory for specific, autobiographical events.
  - accompanied by details about time and place, as well as details about the event itself.
  - "Mental time travel".

"Ah yes, now I remember. I was in Dr. Toth's Cog Psych class, last Wednesday. We were discussing the impact of electronic devices on people's memory ability. I remember looking up and thinking..."

- This is the kind of memory so clearly impaired in anterograde amnesia (hippocampal damage).
Long-Term Memory

✓ Overview: Varieties of LTM.
☐ Encoding into LTM.
☐ Retrieval from LTM.
☐ Implicit Memory.
☐ Memory as Reconstruction.
Problems with the Modal Model

Information is **not** processed serially from SRs to STM to LTM.

STM is **not** the gateway to LTM.

Standard model is too *inflexible* to handle the variety of ways we process info.
Working Memory was one response to the inflexibility of the Modal model. Another response was LoP....
Levels of Processing (LoP)

Memory is better when people think about (attend to) the meaning of words, rather than their sound or appearance. *Implications for learning & studying?*
Levels of Processing (LoP)

Craik & Lockhart (1972)

- Rather than memory being determined by where information is in the system (e.g., STM vs. LTM), memory is more a function of what people do with the information.

- Memory is a by-product of perception, attention, and comprehension.

People remember those aspects of an event that they attend to.
Levels of Processing (LoP)

Intentional vs. incidental encoding:

Intentional encoding: Situation in which you consciously try to commit something to memory.

Incidental encoding: Situation in which you do not consciously try to commit something to memory (but often remember it anyway).
Major Encoding Strategies

Maintenance ("rote") rehearsal: *Intentional* encoding strategy in which person repeats to-be-remembered information over and over.

Non-semantic ("shallow") encoding: *Incidental* form of encoding in which the person attends to the *physical/perceptual* aspects of stimuli.

Semantic ("deep") encoding: *Incidental* form of encoding in which the person attends to the *conceptual/meaningful* aspects of stimuli.
Intentional vs. Deep Encoding

Hyde & Jenkins (1969): Four groups see 20 words, each group using a different encoding strategy

- **Group 1:** Intentional Learning
- **Group 2:** Rate pleasantness
- **Group 3:** Is there an “e”? 
- **Group 4:** How many letters are in word?

![Bar chart showing items recalled by group number with values: Group 1: 16.1, Group 2: 16.3, Group 3: 9.4, Group 4: 9.9]
Why does semantic ('deep') encoding produce such good memory?

Elaboration.

- Craik & Tulving (1975): Three incidental, semantic encoding conditions:
  1) Is an ELEPHANT a mineral?
  2) Is an ELEPHANT an animal?
  3) Is an ELEPHANT a large, grey animal found in India or Africa?

As sentence elaboration increases (from 1 to 2 to 3) so does memory performance. Why?
Why does semantic ('deep') encoding produce such good memory?

Elaboration increases memory by...

1. *Increasing the number of retrieval paths that can lead to the target item.*

2. *Increasing the possibility that you can reconstruct (infer) the target item, even when you can't recall it.*

"Hmmm... I remember reading about a large animal.... oh yeah, a large GREY animal... it must have been ELEPHANT... oh yeah, now I clearly remember it".
Other ways to **Elaborate** information:

- **Associate** info with other info in memory.
- making up a story.
- comparing and contrasting.

- **Form Images**; esp. interactive or bizarre.

- **Relate info to self** (**Self-Reference** effect).
  - *Is _______ a characteristic I possess?*
  - *Do I like this? Why or why not?*

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Any way you can **elaborate** info is going to help you remember that info.
Two critical forms of elaboration are:
- **Organization** - the noting of *similarities*.
- **Distinctiveness** - the noting of *differences*.

**Organization:**
- Memory is better when material is organized by category, as compared to randomly intermixed.
Two critical forms of elaboration are:
  - **Organization** - the noting of *similarities*.
  - **Distinctiveness** - the noting of *differences*.

**Distinctiveness:**
- How unique is the target from other memories?
- The von Restorff effect.
- "Flashbulb" memories.
Memory is best when information is both organized and distinctively processed.

If you're trying to remember...

**Related Things**
(Dog - Cat)

**Unrelated Things**
(Desk - Hammer)

Think about...

<table>
<thead>
<tr>
<th>Similarities</th>
<th>Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Best Memory!</td>
</tr>
<tr>
<td></td>
<td>Best Memory!</td>
</tr>
</tbody>
</table>

Best Memory!
Mnemonics
systematic strategies for remembering information

- First-Letter Elaboration.
  - REACH for a better memory.
  - SQ3R - Survey, Question, Read, Recite, & Review.
  - Mary's violet eyes make John stay up nights (period).

- Method of Loci.
  - putting to-be-remembered info along a mental path.

- The Peg-Word System.
  - interactive imagery for to-be-remembered info.
Mnemonics

- The Peg-Word System.
  - one is a bun, two is a shoe, three is a tree, ....
What have we learned?

- Deeply process the meaning of info.
  - *understand, don't just underline.*
  - what you attend to is what you'll remember.

- Build rich retrieval cues via *elaboration.*
  - more *links* = more memory.
  - *organize:* impose structure & link concepts.
  - *distinguish:* note differences among concepts.

- Use *mnemonics* & distinctive *imagery* whenever possible.
Retrieval from LTM

- All memory is cued; thus, the study of retrieval is the study of how "retrieval cues" work.

Recall vs. Recognition

- **Recall** - generation of target information given a prior context as a retrieval cue.
  - "who was at the party last Friday?".

- **Recognition** - judgment about whether target information was in a prior context.
  - "was Kelly at the party last Friday?".

- Recognition is usually easier than recall. *Why?*
Methods: Free & Cued Recall

- Subjects first study a list of items such as individual words ("truck, cloud, chair, etc.") or word pairs ("rock-spoon, king-prince, etc."). Then...

- **Free Recall** – Subjects simply told to "recall the words from the earlier list in any order".
  - DV = # of studied words recalled [minus intrusions ("recalled" words that were not on the list)].

- **Cued Recall** – S's ask to produce studied items given a cue: e.g., a word stem (tru--), the 1st word from a pair (rock - ?), or an extra-list cue (car - ?).
  - DV = same as above.
Methods: Recognition

- Subjects first study a list of items such as individual words, word pairs, faces, etc.

- **Yes/No (Old/New) Recognition** – Studied ("old") items are mixed together with unstudied ("new") items; subjects must identify the studied items.

- **Forced Choice Recognition** – Subjects shown one of or more items and asked to pick the one that was studied earlier.
  - Two-alternative forced choice (2AFC).
  - Four-alternative forced choice (4AFC); cf. multiple-choice exams.
Retrieval from LTM

Does Deep/Semantic Processing Always Produce the Best Memory?

- Encoding Specificity.

- Transfer Appropriate Processing.

Encoding-Retrieval Interactions (context-/state-dependent memory)
Encoding Specificity
(Tulving & Thompson, 1971)

Study Phase: Words presented (a) in isolation or (b) in the context of weak semantic associates:

a. BLACK, RIVER, CHAIR, etc.

b. train – BLACK, fast – RIVER, rug – CHAIR, etc.

Test Phase: Recall tested under 3 different conditions:

1. Free-Recall ["recall all of the capitalized words"].

2. Cued-Recall with Strong Associates as Cues [e.g., white - ?, lake - ?, table - ?, etc.].

3. Cued-Recall with Weak Associates as Cues [e.g., train - ?, fast - ?, rug - ?, etc.].
# Encoding Specificity

(Tulving & Thompson, 1971)

## Results (% recalled)...

<table>
<thead>
<tr>
<th>Study</th>
<th>Free Recall</th>
<th>Cued-Recall</th>
<th>Weak Assoc.</th>
<th>Strong Assoc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolation (&quot;BLACK&quot;)</td>
<td>.49</td>
<td>.43</td>
<td>.68</td>
<td></td>
</tr>
<tr>
<td>Weak cues (&quot;train-BLACK&quot;)</td>
<td>.30</td>
<td>.82</td>
<td>.23</td>
<td></td>
</tr>
</tbody>
</table>
Encoding Specificity
(Tulving & Thompson, 1971)

The Encoding Specificity Principle
"Specific encoding operations determine what is stored; and what is stored will determine what retrieval cues will be effective in providing access to what is stored".

Remembering is not determined simply by what you do at encoding (cf. LoP). Rather, it reflects an interaction between what you do at encoding and what you do at retrieval.
Transfer Appropriate Processing
(Morris, Bransford, & Franks, 1977)

**Study Phase**: Deep vs. Shallow processing:

a. Deep: The ____ had a silver engine. TRAIN. (Y/N)

b. Shallow: ____ rhymes with *legal*. EAGLE. (Y/N)

**Test Phase**: Recognition tested in 2 ways:

1. **Standard Recog**: TRAIN ... STREET ... EAGLE ... etc...

2. **Rhyme Recog**: GRAIN ... STREET ... BEAGLE ... etc...
## Transfer Appropriate Processing

(Morris, Bransford, & Franks, 1977)

<table>
<thead>
<tr>
<th>Test Type</th>
<th>Study Orientation</th>
<th>Results (% recognized)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DEEP (meaning)</td>
<td>.84</td>
</tr>
<tr>
<td></td>
<td>SHALLOW (rhyming)</td>
<td>.63</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard Recog</th>
<th>Rhyme Recog</th>
</tr>
</thead>
<tbody>
<tr>
<td>.33</td>
<td>.49</td>
</tr>
</tbody>
</table>

Memory benefits to the extent that retrieval processes overlap with (recapitulate) encoding processes.
Encoding-Retrieval Interactions

context- (aka. state-) dependent memory

<table>
<thead>
<tr>
<th>Retrieval Context</th>
<th>Encoding Context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Context A</td>
<td>Context A</td>
</tr>
<tr>
<td>Context B</td>
<td>Context B</td>
</tr>
</tbody>
</table>

Context A

Match!

Context B

Match!
Encoding-Retrieval Interactions
context- (aka. state-) dependent memory

Physical Context: Scuba Diving

% of items recalled...

<table>
<thead>
<tr>
<th>Retrieval Context</th>
<th>Encoding Context</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Under-Water</td>
<td>Under-Water</td>
<td>.32</td>
</tr>
<tr>
<td></td>
<td>On Land</td>
<td>.24</td>
</tr>
<tr>
<td>On Land</td>
<td>Under-Water</td>
<td>.23</td>
</tr>
<tr>
<td></td>
<td>On Land</td>
<td>.38</td>
</tr>
</tbody>
</table>
## Encoding-Retrieval Interactions

*context-* (aka. *state-* dependent memory)

### Emotional Context: Mood

**% of items recalled...**

<table>
<thead>
<tr>
<th>Retrieval Context</th>
<th>Encoding Context</th>
<th>Happy</th>
<th>Sad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Happy</td>
<td>Happy</td>
<td>0.78</td>
<td>0.47</td>
</tr>
<tr>
<td></td>
<td>Sad</td>
<td>0.45</td>
<td>0.80</td>
</tr>
</tbody>
</table>
Encoding-Retrieval Interactions

context- (aka. state-) dependent memory

Subjective Context: Marijuana

% of items recalled...

<table>
<thead>
<tr>
<th>Retrieval Context</th>
<th>Encoding Context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pot</td>
<td>Pot</td>
</tr>
<tr>
<td>Pot</td>
<td>.22</td>
</tr>
<tr>
<td>Placebo</td>
<td>.20</td>
</tr>
</tbody>
</table>
What have we learned?

➢ At study, learn the target info under the same conditions in which you'll be tested.
  ▪ Learn to reproduce the info without notes.
  ▪ Learn to reproduce the info under pressure.
  ▪ When studying, imagine the text context.

➢ At test, mentally reinstate the context(s) in which you studied.
  ▪ Get into the same mental state you were in when you studied (e.g., relax).
  ▪ Recall the study context to create more retrieval cues.
How can we reconcile research on encoding-retrieval interactions (which suggest that memory is best when studied & tested in the same context/environment/state) with more recent research suggesting that memory is best when study contexts and materials are varied?
Recognition Memory Theory

Experience → Recognition Process(es)? → Observed Recognition
Recognition Memory as a Signal-Detection Process

Memory Cue → Strength / Familiarity → Observed Recognition

How does this process work?
Recognition Memory as a Signal-Detection Process

Memory Cue → Strength / Familiarity → Observed Recognition

- Unstudied Items
- Studied Items

Probability

Sensitivity

Rsp. Crit. "No" ↔ "Yes"

signal strength (familiarity)
Recognition Memory: Dual-Process Theory

- **Familiarity**: Signal-detection process (as in SDT)
- **Recollection**: "Memory for details" process (that is not based on strength)
- **Memory Cue**: Observed Recognition

Diagram:

- Arrows from Memory Cue to Familiarity and Recollection
- Arrows from Familiarity to Observed Recognition
- Arrows from Recollection to Observed Recognition

Recognition Memory: Dual-Process Theory

**Recollection** - Conscious/explicit memory for episodic details; "source memory".

- Affected by variables associated with **cognitive control**: Divided Attention, Alcohol, Sleep Dep., Aging, etc.

**Familiarity** - A *feeling* pastness, unaccompanied by the retrieval of episodic details.

- Cf. Deja Vu.
- Unaffected by cognitive-control variables; thus **automatic**.
- Thought by many to reflect a signal-detection process.
Methods: Remember/Know Test

- Subjects first study a list of items such as individual words, word pairs, faces, etc.

- They then take an Old/New Recognition Test (see earlier slide) – but for each word called "old" they must say whether they "Remember" the word as old or just "Know" it was old.

  - Say "Remember" when you can remember specific details about an item's prior presentation.
  - Say "Know" when the word is familiar, but you can't remember any details about it's prior presentation.

- Numerous studies show that "Remember" & "Know" responses are often affected by different variables.